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STAFF REPORT

PREPARED FOR THE

JOINT COMMITTEE ON WASHINGTON METROPOLITAN PROBLEMS

ON

INVESTIGATION OF STATUS AND PROSPECTS FOR THE MASS TRANSPORTATION SURVEY

APRIL 1958

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FOREWORD

The Joint Committee on Washington Metropolitan Problems, as part of its study of the metropolitan transportation problem, has caused the following inquiry into the status of the mass transportation survey. House Concurrent Resolution 172 instructs the committee to examine "how and with what degree of success such problems are handled and resolved by the various agencies and instrumentalities of the Government which are charged with the duty of resolving such problems." The following report has been prepared by Arthur Lazarus, a consultant to the committee. It was completed March 29, 1958.

Mention should also be made of the activities of the Joint Commission To Study Passenger Carrier Facilities and Services in the Washington Metropolitan Area. This commission was created by action of the Maryland State Legislature [1] and the Virginia Assembly.[2] It comprises representatives of these two States and of the District of Columbia, and has commonly been referred to as "the tripartite commission." The importance of this agency as background for the mass transportation survey was cited by Commissioner McLaughlin in his effort to secure congressional support for the appropriation which financed the survey.[3] The commission has been integrated with the mass transportation survey through membership on the steering committee.

FREDERICK GUTHEIM,
Staff Director.

[1] Maryland Senate Joint Resolution 12 (1954). The commission was extended by Maryland Senate Joint Resolution 7 (1956).

[2] Virginia House Joint Resolution 77 (1954). The commission was extended by Virginia Senate Resolution 18 (1956). (The legislation provides "for the establishment of a joint commission to study certain matters relating to passenger carrier facilities in the Washington metropolitan area.")

[3] Hearings before the House Appropriations Subcommittee for the Interior and Related Agencies (Kirwin committee) 1955. The first $200,000 was provided in the Second Supplemental Appropriations Act of 1955. The second $200,000 was provided in the 1957 appropriation act. The final $50,000 was provided in the Second Supplemental Appropriation Act of 1958. (No hearings were held in the House, went directly to the Senate.)

METROPOLITAN TRANSPORTATION

The following report is given with respect to the Washington regional mass transportation survey, its scope and probable findings, the relation such bear to the joint committee's interest in Washington metropolitan transportation, together with recommendations for the further development of the Washington regional mass transportation survey or for other supplementary technical studies of Washington metropolitan area transportation required to meet the assigned duties of the joint committee. Specific consideration has been given to the adequacy of the economic base study, the gravity analysis of regional traffic and the services to be rendered by the Institute for Public Administration as they relate to the general objectives of the joint committee.

In carrying out the aforesaid assignment each consultant contract and correspondence connected therewith have been examined; submitted reports or other evidence of performance have been analyzed; minutes of the survey's steering committee and board of experts have been scanned, as well as working notes and exhibits kept or prepared by the survey staff, to afford the assessment or evaluation of the project which follows.

For convenience the report is presented under the following principal headings:

I. Authorization of mass transportation survey
II. Its development and organization
III. Distribution of funds
IV. General development plan
    Economic base study
V. Traffic volume and potentials
VI. Engineering phase
VII. Miscellaneous technical services
VIII. Regulatory; fiscal, organizational and managerial aspects
IX. Next logical step

I. Authorization of Mass Transportation Survey

The Washington regional mass transportation survey was authorized by congressional action (Public Law 24, 84th Cong., ch. 26) in the following terms:

> For necessary expenses to enable the National Capital Planning Commission and the National Capital Regional Planning Council to jointly conduct a survey of the present and future mass transportation needs of the National Capital region as defined in the National Capital Planning Act of 1952 (66 Stat. 781), and to report their findings and recommendations to the President * * * $200,000 to be immediately available and to remain available until June 30, 1956.
>
> Approved April 22, 1955.

An additional $200,000 was provided by congressional appropriation the following year.

II. Its Development and Organization

The foregoing appropriation had been endorsed prior to passage by the National Capital Regional Planning Council in its February 28, 1955, meeting as a measure to implement the requirement of Public Law 592, 82d Congress, directing the council to participate in making a complete transportation survey for the entire Capital region.

Likewise prior to the approval of Public Law 24, 84th Congress, the National Capital Planning Commission and National Capital Regional Planning Council on April 18, 1955, decided that a committee, later known as the joint committee on program and procedures be set up to formulate plans for an anticipated mass transportation survey.

On June 16, 1955, such joint committee on program and procedures made its report. It contained a series of recommendations which since have had a marked influence on the course of the mass transportation study, suggesting:

(*a*) Employment of a project director.
(*b*) Panel of transportation experts to advise upon and direct the work.
(*c*) Addition of small temporary staff, including two qualified planners.
(*d*) Preparation of a general development plan for the region, and the retention of a qualified consultant therewith.
(*e*) Engaging of consultants or firms on specialized phases of the program.
(*f*) Creation of a joint steering committee to replace the joint committee on program and procedures.

The organization for the study which ensued is essentially a team or group effort, which requires describing before charting.

There are first the two sponsoring agencies, the National Capital Planning Commission and the National Regional Planning Council. Excluding for the moment the key part played by its Chairman, the Commission largely limited its direct participation to administrative help with respect to fiscal controls, appropriations, and disbursements and personnel actions. As will be shown, the Council, through its director and assigned staff actively carried on important segments of the survey. It was thus both a sponsoring and working group.

The sponsoring agencies set up a joint steering committee to supervise the detailed development and execution of the study, comprising 4 voting and 3 nonvoting members. The latter presently include Hon. Robert E. McLaughlin, President, Board of Commissioners, District of Columbia; Hon. H. Lester Hooker, judge, State Corporation Commission, Virginia, and Hon. Frank Harper, chairman, Public Service Commission, Maryland. Two of the four voting members are drawn from the National Capital Planning Commission, namely its Chairman, Harland Bartholomew, and Col. A. C. Welling, Engineer Commissioner of the District of Columbia. The National Capital Regional Planning Council's representatives are Herbert W. Wells, chairman of the Maryland National Capital Park and Planning Commission and Max S. Wehrly, of Arlington, Va., director of the Urban Land Institute.

Advising the steering committee is a board of transportation experts, comprising Donald C. Hyde, general manager of the Cleveland Transit System; Frank W. Hering, deputy director for comprehensive planning, New York Port Authority; Joe R. Ong, transportation consult-

ant, Cincinnati, Ohio, and more recently, W. Pyke Johnson, president emeritus, Automobile Safety Foundation.

Answerable to the steering committee is a project director, Keneth M. Hoover, whose avowed function is to coordinate all aspects of the study. The project director has materially assisted in developing the scope of specialized assignments entrusted to consultants and consulting firms, has kept in touch with the progress of their work, has promulgated desired characteristics, doubtless upon clearance with the board of experts, of proposed alternative transportation networks, and has been in close touch with phases of the survey carried on by the assigned staff of the council, whose director, Paul C. Watt, can be regarded from an activity standpoint as a coproject director. To illustrate this point, brief reference is made to the contributions to the survey which have come from the staff of planners and traffic specialist or from engaged consultants:

1. A general development plan for the region, as of 1965 and 1980, with greater emphasis on the more distant date; proposed land use and distribution of increased population to be shown; using as guidance an economic base study prepared by independent consultants.
2. Graphic analysis of travel habits and movement, as revealed by a 1955 origin and destination study undertaken by the Regional Highway Planning Committee.
3. Tentative highway and rapid transit patterns prepared, with the advice of the project director, as a starting point for consideration by the technical consultants.

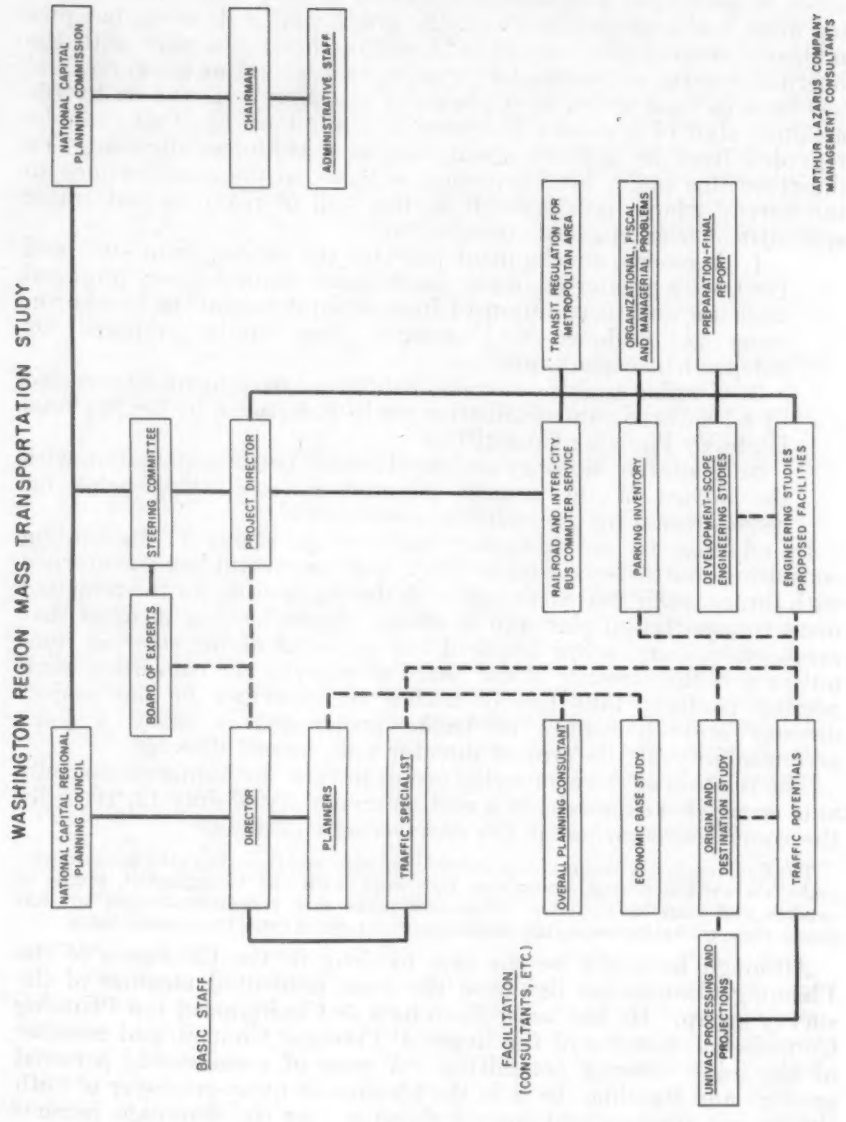
In addition to the foregoing basic setup, about 11 facilitating consulting contracts were made, the 2 most important being concerned with future traffic potentials and with the engineering for the proposed mass transportation plan and facilities. Again bearing in mind that arrangements and scope required the approval of the steering committee and the scrutiny of the board of experts, the consulting engineering contract falls largely within the province of the project director and the study of traffic projections is likely a joint accountability of the project director and council director.

The relation of the sponsoring group toward the numerous consultants engaged is expressed in a written memo, dated July 12, 1957, by the council director anent the engineering consultant:

> The final result is a Commission and Council plan and that they (the consultants) make no written recommendations, but work with the Commission, board of experts and staff as a team. They can make any recommendations to that group they wish; however, the final result will come from the survey team.

Although he might be the first to deny it, the Chairman of the Planning Commission has been the most influential member of the survey group. He has worn three hats as Chairman of the Planning Commission, member of the Regional Planning Council, and member of the joint steering committee. A man of considerable personal prestige and standing, he is in the position of quasi-employer of both the project director and council director. As the dominant personality, a considerable measure of credit or blame for the outcome of the survey can be attributed to him.

The organization for the mass transportation survey, shown on the chart opposite this page, endeavored to cover the ground comprehensively with a small basic staff and the liberal use of consultants.


WASHINGTON REGION MASS TRANSPORTATION STUDY
NATIONAL CAPITAL PLANNING COMMISSION
CHAIRMAN
ADMINISTRATIVE STAFF
ARTHUR LAZARUS COMPANY MANAGEMENT CONSULTANTS
TRANSIT REGULATION FOR METROPOLITAN AREA
ORGANIZATIONAL, FISCAL AND MANAGERIAL PROBLEMS
PREPARATION-FINAL REPORT
STEERING COMMITTEE
PROJECT DIRECTOR
RAILROAD AND INTER-CITY BUS COMMUTER SERVICE
PARKING INVENTORY
DEVELOPMENT-SCOPE ENGINEERING STUDIES
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BOARD OF EXPERTS
NATIONAL CAPITAL REGIONAL PLANNING COUNCIL
DIRECTOR
PLANNERS
TRAFFIC SPECIALIST
OVERALL PLANNING CONSULTANT
ECONOMIC BASE STUDY
ORIGIN AND DESTINATION STUDY
TRAFFIC POTENTIALS
UNIVAC PROCESSING AND PROJECTIONS
BASIC STAFF
FACILITATION (CONSULTANTS, ETC.)

These were engaged over a 2-year period. As a rule their connection with the survey ceased upon the delivery and acceptance of their reports, all of which are now available except the end product from the traffic, engineering and organization technicians.

III. Distribution of Funds

There has been available to the Commission and Council for the mass transportation survey approximately $430,000; $400,000 from Congress and $30,000 through the Bureau of Public Roads. As of February 28, 1958, all but $15,000 had been obligated, $12,000 was needed for June 30, 1958, completion and the remaining $3,000 could be called upon. The funds have prevailingly been prudently expended or committed. Personal services of project director, planning consultant, staff and board of experts are requiring approximately $130,000, printing and binding, $30,000, travel, $6,000, and contractual services, $256,000, of which the engineering contract is for $96,000 and $80,000 in contracts for the processing and projection of traffic volume, form and characteristics, this sum including the use of and programing for Univac. The foregoing costs would have been perhaps $200,000 higher had it been necessary to bear the expense of the 1955 origin and destination study. Probably a like sum is the value of the services contributed by the local agencies. In this sense, the total cost of the mass transportation survey exceeds $800,000. Each of the consulting contracts and arrangements will be discussed in appropriate context.

IV. General Development Plan

The June 16, 1955, report of the joint committee on program and procedures recommended that the initial work of the mass transportation survey "should be the preparation of a general development plan for the region as a basis for the mass transportation plan. This would include the 25-year forecast of population, economic base, land use and zoning." A detailed outline for the suggested first phase of the work was concurrently submitted. The National Capital region was fixed as the District of Columbia, Montgomery and Prince Georges Counties, Md., and Alexandria, Arlington County, Falls Church, Fairfax, Prince William and Loudoun Counties, all in Virginia.

To assist in the preparation of the general development plan, a planning consultant, John T. Howard, was engaged by the mass transportation survey group, on July 8, 1955, with special reference to the problems of population growth and distribution and with respect to land use and existing zoning and previously prepared plans for various parts of the region. As of February 28, 1958, this consultant had given 55 days in such advisory capacity.

ECONOMIC BASE STUDY

Soon thereafter a contract calling for $19,000 was entered into with the Council for Economic and Industry Research, Inc., for a limited economic base study sufficiently comprehensive in scope and detail to develop hypotheses and/or economic formulas to be used in the projection of population growth, employment, and land use within the National Capital region for the design years 1965 and 1980.

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The contract scope included the following subsections, wherein, in our judgment, the CEIR report, submitted June 30, 1956, is weak:

Government employment—Generalized answers required

Long-range trends in income—civil and Armed Forces—compared with private employment: Do not find.

How will changes in civil-service requirement and social-security provisions increase Washington's attractiveness as a residential city for retired people? Not specifically dealt with; estimate of in-migration of all types of retirees, 1965 and 1980, is, however, given.

Influence of shortened Government workweek in 10 and 25 years: Not found.

Special technological changes—automatic data processing machines, new forms of communication and reproduction: Only sketchy reference thereto.

Economic effect upon central business district if future employment west of Capital is limited to 140,000: Not shown; in fact lack of any treatment of central business district is an obvious omission.

Industrial and trading potentialities

The contractor will make a limited field study of present and future trading developments in the National Capital region on the basis of approximation of potentialities only, and develop findings with respect to the following: No evidence of field study found.

Actual experience of representative new industries in the National Capital region: Not found.

The long-range expansion expectations of the plants in the National Capital region as compared with their affiliates or competing plants in other regions: Not found.

Likelihood that other plants of the same or related industries may locate in the National Capital region: Not found.

Availability of labor, skilled personnel, and capital for possible expansion of industry in the National Capital region: Partially given.

General competitive position of certain industries in and outside the National Capital region: Given.

Reasons for the apparent lagging of some of the old, established industries in the National Capital region: No.

The industry section of the report is rather a key one, since its authors believe that only a development of industry more nearly approaching the regional potential will warrant or call for the resumption of the rapid in-migration of recent years. It is stated that the 1955 level of industrialization was about 15 percent of full achievement, but how the 100 percent of industrialization is determined is not apparent, except perhaps in terms of what the resulting mass market could justify, if self-sustained.

Irrespective of its broad brush character, the CEIR report is ingeniously conceived and adequate for the purpose for which it is intended. It is acceptable as a guide for the construction of a general development plan, to the overall requirements of which future regional transportation plans will be geared. The report, however, definitely does not meet the requirement of the intensive studies the joint committee will need in its consideration of the economic development latent in the Washington metropolitan region.

GENERAL DEVELOPMENT PLAN

According to the last word, the general development plan as it will appear in the mass transportation survey report will be a stripped-down production; a more complete presentation is later to appear as a technical paper. Land use for 1980 and not separately for 1965 will be delineated. Reservation of land for a possible Great Falls dam and lake site, protection of the purity of the Potomac water supply, as well as of drainage areas, are provided in the proposed land use. Land is eliminated for use where unfavorable soil conditions are known. Airport requirements and defense considerations are taken into account.

Council staff has prepared 1955 National Capital regional statistics by transportation zone and district as used in the survey of origins and destination of traffic movement, of population, dwelling units, labor force, employment, income group, retail sales in dollars and percent of regional total, for which a summary is shown opposite this page. This was meant as a working document for the traffic consultants. Minor variations with other tabulations exist. It is reproduced here, as table I, solely for the enlightenment of the joint committee.

TABLE I.—*Summary of selected 1955 statistics applicable to the National Capital region*

City or county	Population	Dwelling units	Labor force	Employment	Retail sales		1955 median family income [1]
					Amount	Percent	
					Thousands		
District of Columbia	840,409	296,641	404,470	503,000	$1,212,450	58.72	$4,750
Montgomery:							
Inside traffic cordon	209,228	60,971	86,104	52,600	210,100	10.18	.....
Outside traffic cordon	61,500	17,050	25,130	14,250	27,550	1.33	.....
Total	270,728	78,021	111,234	66,850	237,650	11.51	7,600
Prince Georges:							
Inside traffic cordon	210,387	61,644	87,116	42,500	153,850	7.45	.....
Outside traffic cordon	75,000	22,430	31,885	18,950	29,150	1.41	.....
Total	285,387	84,074	119,001	61,450	183,000	8.86	5,900
Arlington	152,267	53,884	68,799	97,900	181,300	8.78	6,900
Alexandria:							
Inside traffic cordon	81,722	26,228	35,175	26,900	120,100	5.82	.....
Outside traffic cordon	500	140	230	1,450	200	.01	.....
Total	82,222	26,368	35,405	28,350	120,300	5.83	5,900
Fairfax County and Falls Church:							
Inside traffic cordon	74,509	20,349	28,778	13,100	47,300	2.29	.....
Outside traffic cordon	107,000	34,730	48,085	22,600	37,200	1.80	.....
Total	181,509	55,079	76,863	35,700	84,500	4.09	[2] 6,900
Prince William	37,000	14,030	16,880	15,050	24,200	1.17	.....
Loudoun	23,000	6,220	8,350	7,700	21,400	1.04	.....
National Capital region	1,872,522	614,317	841,002	816,000	2,064,800	100.00	.....

[1] From CEIR report, p. 11.
[2] In 1953, $6,000.

EMPLOYMENT AND POPULATION

A mass transportation survey staff presentation gives the following further analysis of 1955 employment:

TABLE II.—*National Capital region population, 1955*

	Federal	Commercial	Industrial	Other	Total
District of Columbia	195,000	203,000	64,500	40,500	503,000
Montgomery County	16,000	29,500	5,450	15,900	66,850
Prince Georges County	18,500	21,900	6,050	15,000	61,450
Arlington County	55,000	25,150	8,300	9,450	97,900
Alexandria	1,900	17,200	6,050	3,200	28,350
Fairfax and Falls Church	16,700	10,350	2,600	60,050	35,700
Prince William County	8,850	2,900	850	2,450	15,050
Loudoun County	50	2,650	750	4,250	7,700
Total	312,000	312,650	94,550	96,800	816,000

The mass transportation survey staff planners have accepted as targets for future population, 1965 and 1980, figures in their judgment as low as can be reconciled with natural population trends and the healthful growth of the economy of the region. Such correspond to a range of level of industrialization by 1980 between 20 and 30 percent of potential against a CEIR estimated present of 15 percent; the use of intermediate birth rates and a level of inmigration ranging from 25 to 50 percent of the 1950–55 level to 1965, and dropping thereafter well below 25 percent. On this basis, target population ranges set for the general development plan are—

1965 ..... 2,300,000 to 2,500,000
1980 ..... 2,750,000 to 3,250,000

Projected population growth in the order of 600,000 by 1965 and 1,200,000 by 1980 devolves upon the planner 2 problems, one of settlement and the other of employment allocation.

In order to facilitate the locating of 600,000 persons in the region (the 1955 to 1965 increment) the survey staff planners adopted their consultant's recommendation to use a density classification scheme based upon the number of acres each 1,000 persons would need under 4 assumed densities. These 4 categories were based upon an averaging of existing conditions locally; to wit, 40 acres for 1,000 persons as equivalent to a garden-type-apartment density; 75 acres per 1,000 persons as equivalent of high-density single-family development; 100 acres per 1,000 persons as equivalent to low density single-family development; and 200 acres per 1,000 persons as equivalent to quite low density estate-type development.

Below is a table showing apportionment of part of projected 1965 growth by these four density classes:

TABLE III

Montgomery County:	
Inner areas:	
40 acres per thousand population (125 acres)	3,000
100 acres per thousand population (7,225 acres)	72,000
200 acres per thousand population (3,475 acres)	18,000
Scattered growth	7,000
Outer areas:	
Rockville	10,000
Germantown	5,000
Scattered growth	20,000
Total	135,000
Prince Georges County:	
Inner areas:	
40 acres per thousand population (135 acres)	3,400
75 acres per thousand population (7,000 acres)	93,600
100 acres per thousand population (1,590 acres)	15,900
200 acres per thousand population (1,275 acres)	6,100
Scattered	11,000
Outer areas	15,000
Scattered growth	20,000
Total	165,000
Fairfax (plus Falls Church):	
Inner areas:	
100 acres per thousand population (5,900 acres)	59,000
200 acres per thousand population (3,600 acres)	18,000
Scattered growth	13,000
Outer areas: All scattered growth	20,000
Total	110,000

Scattered growth is that growth which cannot be accounted for in subdivisions.

Thus about two-thirds of the 1965 expected increase in population were located by application of graded densities. The survey staff felt this scheme was not applicable in the District of Columbia or in Arlington, and used the densities only in the west portion of Alexandria where the land is still open. Within the builtup areas reliance was placed upon the local planners for the population capacity of each origin and destination area.

The survey staff planners considered it was not necessary to adhere to the density formulas after 1965, because the inner areas were either at capacity by then or very close to it and because the origin

and destination districts in the outer areas of the region were of great size, each having several thousand acres, so that no fitting problem was encountered. The origin and destination area across from the proposed Jones Point Bridge, cited as an example, has 9,000 buildable acres. At the high density single-family classification that area could house 100,000 to 120,000 persons.

With the foregoing in mind, the population distribution arrived at by the mass transportation survey for the National Capital region for 1965 and 1980 is shown below:

TABLE IV.—*Projection of population—1965, 1980*

	1955	1965	1980
National Capital region	1,860,000	2,300,000–2,500,000	2,750,000–3,250,000
District of Columbia	850,000	880,000– 920,000	900,000–1,000,000
Montgomery County	255,000	360,000– 420,000	500,000– 620,000
Prince Georges County	290,000	410,000– 480,000	530,000– 650,000
Arlington	155,000	190,000– 210,000	200,000– 210,000
Alexandria	85,000	105,000– 115,000	110,000– 130,000
Fairfax County and Falls Church	165,000	260,000– 300,000	410,000– 520,000
Loudoun County	23,000	25,000– 27,000	30,000– 42,000
Prince William County	37,000	43,000– 47,000	50,000– 80,000

To Montgomery, Prince Georges, and Fairfax Counties are allocated the largest increases, 70 percent of the total. It is believed by the survey staff that the central districts—the District of Columbia, Arlington, and Alexandria, will be developed to or close to capacity by 1980 or before.

Employment

A general development plan requires not only the projection of population, but of employment and the location of employment as well. Estimates of total employment by major categories, consonant with population estimates, and based in part upon the CEIR analysis, have been formulated, to wit:

TABLE V

	1955	1965	1980
Federal Government	312,000	320,000–350,000	330,000–400,000
Commercial employment	312,000	370,000–410,000	430,000–530,000
Industrial employment	95,000	120,000–140,000	150,000–210,000
Other employment	97,000	105,000–115,000	125,000–150,000
National Capital region	816,000	930,000–1,000,000	1,080,000–1,260,000

Federal employment

The first draft of the general development plan contains much verbiage concerning the principles which should control the location of Federal employment. Actually we do not believe the mass transportation survey ever came to grips with this problem, or in the absence of an ascertained prevailing policy, felt strong enough to take the leadership in developing one. The validity of the so-called test of interaccessibility is open to debate. Hence known plans for the location of Federal employment outside of the central district were given cognizance, and developments beyond 1956 shown at new, more distant locations in Montgomery, Prince Georges, and Fairfax Counties, as representative of new or relocated hypothetical agencies.

The following table gives the projected distribution of Federal employment by county:

TABLE VI.—*Projection of Federal employment, 1965 and 1980*

	1955	1965	1980
National Capital region	312,000	320,000–350,000	330,000–400,000
District of Columbia	195,000	187,000	211,000
Montgomery County	16,000	26,000	30,000
Prince Georges County	18,500	27,000	31,500
Arlington County	55,000	53,000	48,000
Alexandria	1,900	2,400	4,400
Fairfax and Falls Church	16,700	30,000	34,000
Prince William County	8,850	9,000	11,000
Loudoun County	50	100	100

Commercial employment

The preliminary general development plan makes obeisance to the magnetic pull of the central business district for such independent sectors of the economy as international agencies, specialized professional services, convention and tourist hotels; commercial activities which require accessibility to the entire metropolitan market, administrative and headquarters offices, finance, business services, entertainment; also the retail and consumer services that cater to the concentration of Federal employees and the aggregate of resident population there. Nevertheless, of total increase in projected regional commercial employment by 1980, only 22 percent is allocated to the District of Columbia.

Present in the minds of the planners is the regulation that the commercial activity needed to serve an expected increase of a million suburban population by 1980 will require a considerable acreage, with provision of several times as much land for parking as for buildings. New commercial land-use areas originally shown separately for 1965 were those projected as most probable of immediate development in the judgment of planners of the local jurisdictions, the size of the sites of which were calculated in terms of the tributary markets. New business areas additionally provided for 1980 are limited to the few of subregional importance. There is a seeming contradiction in the preciseness with which retail sales are estimated for 1980 for purposes of traffic approximation by each of over a 100 districts and the grudging reluctance to definitize the location of commercial centers.

In any event the projection adopted for commercial employment 1965 and 1980, in the National Capital region is shown herewith:

TABLE VII.—*Projection of commercial employment, 1965 and 1980*

	1955	1965	1980
National Capital region	312,000	370,000–410,000	430,000–530,000
District of Columbia	203,000	217,760	237,360
Montgomery County	29,500	45,550	69,650
Prince Georges County	21,900	38,100	58,400
Arlington County	25,150	29,150	33,150
Alexandria	17,200	20,700	25,000
Fairfax and Falls Church	10,350	25,250	43,625
Prince William County	2,900	4,300	6,400
Loudoun County	2,650	3,900	5,100

Industrial employment

Industrial employment which includes that entailed by warehousing, lumber and fuel supply, utilities, transportation and wholesaling, is expected to double by 1980, requiring additional land to be devoted to industrial purposes. Only 20 percent of the 1980 increase in industrial employment is projected for the District of Columbia.

The location and extent of new industrial land use projected for 1965 reflected the opinions of the planners of the local jurisdictions as to suitability of sites and likelihood of development and also a recognition of the trend in zoning policy in various parts of the region. For 1980 generalized recommendations are made of further growth of industry into distinctly more outlying locations.

Total employment

As a matter of record, projections of total employment for 1965 and 1980 are given. The 1955 figures have had minor adjustments to reconcile with table 4 of the preliminary general development plan.

TABLE VIII.—*Projection of total employment, 1965 and 1980*

	1955	1965	1980
National Capital region	816,000	930,000–1,000,000	1,080,000–1,260,000
District of Columbia	503,000	510,000– 530,000	550,000– 610,000
Montgomery County	66,850	95,000– 105,000	120,000– 160,000
Prince Georges County	61,450	90,000– 110,000	120,000– 160,000
Arlington	97,900	100,000– 110,000	100,000– 110,000
Alexandria	28,350	30,000– 40,000	40,000– 50,000
Fairfax County and Falls Church	35,700	65,000– 85,000	100,000– 130,000
Prince William County	15,050	16,000– 20,000	22,000– 28,000
Loudoun County	7,700	9,000– 11,000	10,000– 16,000

Recreation and open spaces

The proposed land use plan seeks to make appropriate provision for recreation and other open spaces. The following abstract bearing on such is taken from the November 5, 1956, memo by John T. Howard, planning consultant on policies for a regional land use plan for the National Capital region.

> The land use plan proposes the preservation of major open spaces for recreational or other reserved uses in all locations where natural conditions invite their consideration. * * * The total area proposed is not out of line with current "acre-per-thousand-population" standards for such reservations, if the standard is applied to that "ultimate" population which may be reached many decades from now.

While reservation of land for recreational or other reserved use may be far reaching, the provision for green wedges or green belts in the preliminary general development plan appeared to be inadequate. These green wedges or green belts are proposed for continued rural use to provide the insulation between communities and the developmental flexibility required by good planning.

Circulation

The land use plan likewise makes provision for circulation proposals, generally developed from the review of the patterns of employment concentrations, population distribution, and urban and open uses of land.

Characterization of plan

It is not necessary to comment extensively upon the general development plan. The promulgators largely take care of this requirement. It is characterized by them in a preliminary description thereof as not a "bold" plan, and as "general in nature, providing no more than the minimum framework for the transportation analysis it was prepared to support."

V. TRAFFIC VOLUME AND POTENTIALS

On April 20, 1956, the National Capital Planning Commission on its behalf and that of the National Capital Regional Planning Council entered into a contract with Wilbur Smith Associates for a study and report providing an analysis and projection of traffic volume and potentials to two or more alternate mass transportation plans to facilitate optimum movement of people within the National Capital region for design years 1965 and 1980. Under the specifications of the contract:

> The contractor is required to survey, analyze, and project traffic volumes and potentials both inside and outside the outer cordon established by the Washington area transportation study including, but not limited to, study and analysis of existing travel patterns, volumes and time use extended to satisfy future traffic potentials and volumes annually for the years 1955 through 1980 and [to] indicate travel desire lines, related time schedules, fare rates, and economic justification applicable to two or more alternate mass transportation plans.

Contractor undertook to "furnish estimates of travel by automobile and mass transportation, within the geographic limits of the survey for the years 1955, 1965, and 1980, with projections for intervening years, [to] relate same to time, distance, volume," and "show desire lines and trip generation between locations for design years"; contractor to "make a detailed analysis of the basic characteristics of travel to determine measures of relative trip generation between the many subdivisions in the National Capital region, commuter locations, and intercity travel."

Contractor was also obligated to "develop from the general development plan estimates of the volume and distribution of trips made within the survey area by applying trip generation characteristics available from the 1948 and 1955 Washington area transportation studies, [to] assist the survey staff, panel of consultants, and the Commission in developing two or more alternate mass transportation plans" and to "consider such plans with the coordinate thoroughfare plans of the National Capital region, as supplied by the Commission and Council, for the assignment of travel" and to "project and assign travel volumes to two or more alternate mass transportation plans and to the coordinate National Capital regional thoroughfare plans; such assignment of volume and distribution of travel [to] take into consideration travel desire data for each intervening year (1956 through 1980) giving consideration to the following:

(1) Optimum rate schedules for transit, based on trip use for different rate schedules.

(2) Optimum time schedules for transit use (a. m. and p. m. peaks of 3 hours each [later modified to 2 hours] at ½-hour intervals, And other hours at 1-hour intervals).

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(3) Evaluate traffic flow as related to current and future street and highway capacities (a. m. and p. m. peaks of 3 hours each [later modified to 2 hours] at ½-hour intervals and other hours at 1-hour intervals) and [to] illustrate the relationship between capacities and demand for the various proposed systems.

Also to "measure the potential volume to and within the area defined by report on inner loop freeway system, dated October 1955 and [to] estimate present and future parking requirements for the years 1956 through 1980 as may be related to proposed mass transportation plans."

Contractor also agreed to "develop estimates of annual income and operating costs for the two or more alternate transit systems for each of the 25 years (1956 and 1980), the estimates of income [to] be suitable for use in an economic analysis for subsequent development of a financial plan; the whole foregoing ground to be comprehensively covered in a preliminary and final report, which would also also include a description of analytical techniques used, with applicable support data."

It is obvious that the fulfillment of the foregoing scope would tax the ingenuity and industry of the selected contractor.

The following information and data was represented as available or to become available to the contractor:

1. Washington metropolitan area transportation study:
   (*a*) 1948—origin and destination survey (punched IBM cards)
   (*b*) 1955—origin and destination survey (punched IBM cards) promised as available on or before July 1, 1956, but believed delayed in availability
2. General development plan data for the National Capital region:
   1955 population, employment, and land use (percent) by districts and/or zones inside outer cordon (Washington area transportation study) and by census tracts and magisterial districts outside of such cordon; ditto for 1965 and 1980 population and employment forecasts and land use projection.
3. Commuter and intercity transportation service of railroads and buslines.
4. Parking information to be developed by the District Motor Vehicle Parking Agency and survey staff.
5. Air travel.
6. Reports relating to highways, bridges, comprehensive plans.
7. Operation study of currently existing transportation system.
8. One or more alternate National Capital regional thoroughfare plans.

The contract called for $48,000, of which $24,000 have been paid, plus half the cost amounting to $7,500 for a consultant programer for the mechanical processing of traffic data by Univac, plus the rental of computing equipment time amounting approximately to $25,000.

The contractor, Wilbur Smith & Associates, is probably the most experienced firm in the country in the field of traffic studies. Its principal, Wilbur Smith, is Chairman of the Department of Traffic and Operations of the Highway Research Board of the National Academy of Sciences; is associate director, bureau of highway, traffic,

Yale University, and technical consultant of the Eno Foundation for Highway Traffic Control. The project director for the assignment, Houston F. Wynn, is a member of the committee on origin and destination studies set up by the Highway Research Board.

DIFFICULTIES AND DELAYS

Presentation of the traffic projections and allocations have been delayed. A relatively new and hoped for improved method of long range traffic projection has given rise to unanticipated problems. Preliminary estimates have been provided. Revised figures are promised not later than May 23, 1958.

METHOD

The method employed by the traffic consultant commands considerable interest. Although the method has not been adequately described, various partial explanations of the techniques employed by the traffic consultant have been supplied; to wit: Descriptions of Techniques to 1965 and 1980 (undated but probably issued in the fall of 1956), Methods of Trip Assignment to High-Speed Public Transportation, June 19, 1957; Assignment of Travel to Highways and Transit, July 19, 1957, and Urban Travel Projections and Assignments to Highways and Transit—1965 and 1980, October 12, 1957. The last omits mention of the formulas employed and is perhaps too generalized, but it is the most lucid of the various memorandums, and for that reason, is reproduced in the appendix.

Nowhere is there an explicit reference to the use of the gravity model method, but possibly oblique reference can be found in paragraph 3, page 7, of the October 12, 1957, memorandum.

Distribution of trips between origins and destination is the next problem. Plots of data, by purpose, found that the rate of travel between origins and destination is universally related to the distance between trip generators and directly proportional to their size.

On March 19, 1958, the staff director of the joint committee obtained the following information from one of the staff of the Baltimore Regional Planning Council where the gravity-model technique is being used in its metropolitan transportation study, because in the absence of an origin and destination study, no other method would have yielded any dependable results in the time and resources available.

The technique as reported involves a series of land-use analyses, from each of which empirical formulas of traffic generation have been developed. The pull of industrial, commercial, recreational and other sources is measured in size and travel distance. Further estimates are made of major shopping and employment centers. These transportation needs are translated into "desire lines" and values, varying from area to area. Projections of future traffic that are developed from these techniques are being tested by actual traffic counts before they are used.

In the case of the Washington metropolitan area several origin and destination studies were available. Of the projected 1980 population for the Washington metropolitan area two-thirds is expected to reside inside the traffic cordons established by the 1955 origin and destination study and one-third without. Perhaps it would have

been prudent to have adopted well-tried methods of traffic projection for the movement within cordon districts and more experimental methods for that outside.

VI. Engineering Phase

Prior to entering into a contract for the engineering phase of the mass transportation survey, a small preliminary contract of $3,500 was given to Jackson H. Taylor on July 20, 1956, for the following purposes:

Investigation of aerial photographs, maps, data, and other materials available in various United States Government agencies, departments of adjacent States, and District offices; pertaining to highway and transit design with an evaluation of their use in connection with mass transportation study.

An investigation and report on the feasibility of the use of the photogrammatic method of ascertaining the selection of economical locations for rights-of-way and as a foundation for engineering estimates.

Study and report on unit cost design material for highway and mass transportation cost estimates, advising the mass transportation survey staff as to the feasibility of the use of such method by an engineering organization retained to make a reconnaissance, design engineering and cost estimate study; and

Preparation of a definite specification and proposal to cover all parts of the proposed reconnaissance, design engineering and cost estimate study.

Presumably the foregoing is the genesis of the January 9, 1957, outline of proposal for the engineering phase of the Washington regional mass transportation survey, a contract for the carrying out of which was given March 19, 1957, after interviewing various firms, to DeLeuw, Cather & Co., Chicago, Ill., one of the best-known and most experienced engineering firms in the transportation field. It was familiar with the Washington area, having had a somewhat comparable assignment in 1944.

DE LEUW, CATHER & CO. CONTRACT

The De Leuw, Cather contract is the single most important contract let by the mass transportation survey and extensive quotation will be made of its provisions:

Basic Transportation Plans

Contractor will develop general engineering plans and cost estimates for the physical facilities of a minimum of three basic transportation plans to facilitate optimum movement of people and vehicles within the National Capital region for the initial year of operation, for 1980, and by interpolation for the intervening years. The purpose of the study of alternate schemes is to ascertain the relative economic validity of the several basic methods for moving masses of people, and to permit of a determination of the most desirable and practicable means of providing mass transportation for the National Capital region.

(General engineering plans and cost estimates are not to be detailed working plans and firm or precise estimates, but should be sufficient to show location of facilities and structures involved, and cost estimates related thereto should be determined on the basis of reasonable, current and applicable unit price costs for such facilities and structures.)

The contractor shall collaborate with the board of experts, with the survey staff of the Commission, and with such others as may be necessary in the preparation and development of the three basic plans and the final plan.

The three basic transportation plans referred to include, but are not limited to facilities for the several modes of transportation designated below as:

Basic Transportation Plan I—Automobile dominant

A possible all motor-vehicle solution to the problem of the movement of people and vehicles in the region involving the construction and improvement of parkways, expressways, thoroughfares, and streets of the proposed arterial highway system, including parking facilities, adequate to meet the demands of anticipated traffic.

The mass transportation component of this plan will be the bus operating in mixed traffic over major streets and traffic ways.

Basic Transportation Plan II—Express bus

This plan is predicated upon a substantial reduction in the required highway capacity through the utilization of express buses operating on major streets and trafficways in the central business districts and the outlying areas but with their own grade separated rights-of-way along the regional traffic corridors as they approach the central city. Local buses would provide service similar to the present, with route changes and additions to serve the express bus system.

Bus terminal facilities may be part of this plan. Parking facilities for the automobiles at the urban center and outlying bus stations would be required.

Basic Transportation Plan III

The basic feature of this plan is a modern rail or other high-speed transit system, operating on grade separated right-of-way with the arterial highway system constructed and improved so that each system complements the other to provide optimum service. It is to be assumed that local bus service would remain similar to the present with route changes and additions, as required to serve the high-speed system. Parking facilities for the automobile would be required at the urban centers and the outlying transit stations.

Final plan

The information obtained from the three basic transportation plans will be used by the contractor, in cooperation and consultation with the Commission, to formulate a plan for a mass-transportation system to facilitate the optimum movement of people and vehicles for the National Capital region.

Specific requirements

The contractor is to perform the following work with respect to the three basic transportation plans and the final plan:

(*a*) Make general engineering plans showing the most feasible and practicable location for the highways, express bus, and rail or other transit system, including central delivery, within the general locations furnished by the Commission. Selection of the recommended location in each case shall be made on the basis of cost of construction, cost of right-of-way, minimum disturbance to homes and businesses, location of interchanges, stations, terminals, garages, yards, shops, and parking facilities, and shall provide optimum service to the traveling public consistent with the accepted design standards applicable to the type of transportation facility indicated for the route under consideration. Where two or more locations appear equally satisfactory, the advantages of the recommended location shall be documented as a basis for comparison.

(*b*) Make general engineering plans, showing the essential features of each transportation route and including, but not limited to, intersecting highways, interchanges, stations, terminals, parking facilities, structures such as bridges, tunnels, subways and elevated ways, garages and yards, and shops.

(*c*) Prepare schematic drawings to illustrate the general character of typical interchanges, stations, terminals and parking facilities proposed for each of the three basic transportation plans and for the final plan.

(*d*) Make a preliminary estimate of the current cost of construction and right-of-way for each of the three basic transportation plans and the final plan; such estimate to show the cost of each route separately by major components.

(*e*) Describe and recommend the power-supply system, the dispatching, signal, and communications systems, fare-collection systems and necessary appurtenances, accessories and procedures for the operation of the mass transportation portions of plan II, plan III, and final plan, excepting local buses.

(*f*) Study the various types of mass-transportation equipment which may have application to plan II, plan III, and the final plan, and recommend the most suitable types of equipment for each plan. This study shall include consideration of various modes of transportation such as express buses, supported and suspended trains, carveyors, moving sidewalks, etc.

(*g*) Estimate the amount and cost of the recommended mass-transportation equipment for plan II, plan III, and the final plan, based on the travel demands furnished by the Commission.

(*h*) Estimate the annual operating costs for plan II, plan III, and the final plan, and total costs for the three basic transportation plans and the final plan, for the initial year of operation and for the intervening years.

(*i*) Prepare a program of stage construction for the final plan, including capital expenditures required for each stage.

Provision is also made for the customary comprehensive preliminary and final report under the specific requirements. Under General Requirements the following may be noted:

Revisions of the three basic transportation plans furnished by the Commission as may be suggested by the contractor or indicated by the development of the survey, may be required during the progress of the work.

It is essential that the estimates of cost for each of the three basic transportation plans be comparable as to capacity of facilities required. It is also essential that all four plans as developed afford the same level of comfort and convenience for the same overall volume of person movement.

If, however, any of the plans, when measured by accepted standards, should fail to provide adequate traffic capacity, during any period, the contractor shall point out such deficiencies in his report.

The contractor shall study all pertinent available information and data and prepare general engineering data relating to circumferential and central city parking facilities and requirements including location, capacity, construction costs and annual operating costs, for each of the three basic transportation plans and the final plan.

Under the contract certain information and data was to be made available to the contractor, including—

(1) Coordinated highway plans, including design and location, available for the Interstate Highway System in the District, Maryland, and Virginia, as may be related to the National Capital region, to the year 1975, and construction costs for such highways when available.

(2) Coordinated highway plans, including design and location, for the District and Virginia State systems related to the National Capital region to 1970 and applicable construction costs; comparable plans and construction costs for the Maryland State Highway System, related to the National Capital region, to 1966.

(3) Inventory of all available information and data relating to current offstreet and onstreet parking facilities, including capacities, location, and usage.

(4) Location and design for parkways within the National Capital region to 1975.

(5) Volumes and desire lines for travel within National Capital region for 1955, 1965, and 1980; as well as assignment of travel to the highway and parkway systems indicated in (1), (2), and (3) for measure of capacity deficiencies.

The function of the engineers then is to provide verisimilitude to the barebone transportation plans or presentments provided by the mass transportation survey staff; to offer suggestions for supplementation, combination, amendment, and elimination; to adjust or call attention to expectations which seem unrealistic or unrealizable, to indicate an advantageous choice in a series of alternatives; to foot up the estimated bill for construction and operation; but not to come up with a full-blown system or transportation plan in detail requisite, let us say, for financing. What may be expected, it is believed, is a scheme which will afford a broad vista of the inherent problems and serve usefully as a starting point for further study and discussion.

ENGINEERING PROGRESS

The few differences which have developed, and none of them have been critical, between the engineering consultant and the mass transportation group have been due to differing perspectives. That of the mass transportation group may be termed one of calculated optimization; that of the engineering consultant one of practicality, the outcome of wrestling with many transportation situations.

The mass transportation survey viewpoint is reported in the minutes of the February 11, 1958, meeting of its expert advisory group when one of the panel outlined the basic policy position, thereupon adopted, that he believed the expert advisory group should take.

> He suggested that complete consideration should be given to the optimum transportation requirements of the metropolitan area in order to provide guidance to the governmental officials and transportation and highway engineers in planning, staging and financing such needs. This could not be accomplished if the analysis of such needs were limited to plans provided by present highway programs which, of necessity, must be based upon funds allocated to that purpose. The broader approach would provide a better foundation for judgment in scheduling future facilities, allocating available funds and through an informed public, would support officials in obtaining additional financing where such will be needed to satisfy demand. The plan, as finally published, should show requirements regardless of limitations.

With the foregoing as background, the development of the engineering assignment is discussed.

On April 25, 1957, the engineering consultant submitted several sketches and likewise a list of statements, assumptions, and operating techniques with respect to rail and bus rapid transit. One sketch shows a typical cross section of a six-lane freeway with a private right-of-way for transit operation. The space allotted for transit could be used for buses or rail vehicles. The sketch also shows a station to serve buses operating in the general traffic stream. The idea is that the use of various portions of such typical crosssection will give almost any type of facility likely to be required in the Washington metropolitan area. The sketch is for a freeway below the grade of the surrounding area, but according to the engineering consultant a similar design could be developed for a freeway on fill.

A second sketch shows a plan for a center-platform station with a private roadway for transit operation, a concept more practical for rail operation than for bus.

The advantage and disadvantages of rail and bus rapid transit as encompassed in type of equipment, outer terminal, intermediate stations and downtown distribution facilities are listed as well as operating requirements with respect to collection facilities, line operation and downtown terminal facilities.

The foregoing in a sense represents the initial contribution of the engineering consultant.

On July 19, 1957, the engineering consultant, through D. W. Cather, submitted a memorandum outlining the agreement reached as to the scope of the engineering consultant's studies, of which the following abstract is given:

> The question of the method to be used to produce tabulations and desire line charts indicating the 1955, 1965, and 1980 rush-hour origin-destination traffic pattern and the all-day pattern was brought up for discussion by D. W. Cather. It was agreed that separate data would be prepared by the traffic consultant for DeLeuw, Cather's use; the basis of such being that the origin and destination

during the rush hour, presumably 5 to 6 p. m. would be selected from the basic data for the work, social, business, and miscellaneous categories (of trips) and assembled into a triangular table. The several discussions terminated in the following agreement as to the scope of DeLeuw, Cather's studies:

1. When the traffic data have been delivered, DeLeuw, Cather will prepare and submit a comprehensive plan to accommodate the traffic which may be attracted to public transit as of the years 1965 and 1980. The plan may be based on a system with rail rapid transit dominant, buses dominant, or automobile dominant, or the system may be composed of various types of transportation facilities. Preliminary plans and estimates will be submitted to the board of experts covering this composite recommended plan. In addition, preliminary plans and estimates will be prepared to show the scope as well as construction and right-of-way costs of providing transportation service for the Washington metropolitan area on the basis of an all-rail rapid transit, all-bus and all-automobile plan. These three plans and estimates for the alternate schemes will not be prepared to the same degree of refinement as for the recommended plan but will be executed so as to give a reasonably accurate comparison between the available alternate schemes.

2. Estimates of operating expenses will be prepared similarly for the recommended plan and the alternate schemes. In addition, we will assume the responsibility of including in our report estimates of revenue if we are provided with the fare schedule and the estimates of riding, both to be prepared by other consultants.

3. In preparing the recommended plan, every effort will be made to utilize realistic travel speeds based on the maximum station spacing in the urban and suburban areas. Economically sound operating headways will be developed on the basis of the preliminary assignments which will determine the traffic volumes in the rush, base, and evening hours, respectively.

4. It is recognized and agreed that available data will not permit the subdivision of the large zones within the zero sector (central business district) by the traffic consultant, and therefore De Leuw, Cather will, if at all possible, cooperate with the staff of the National Capital Planning Commission in the determination of the employment within zones in the zero sector, and we will make comparative travel time studies to the delivery sectors, which travel times will be computed with the cooperation of the traffic consultant to be used for the final assignment of the recommended plan.

5. The traffic consultant will be responsible for making assignments to the final recommended plan, based on the scheduled speeds and headways developed by De Leuw, Cather with the approval of the board of experts. These will also be utilized to adjust the assignment of traffic to the alternate schemes either by modification of the original assignment made to the tentative plans, or, where necessary, by complete recalculation by the traffic consultant of the comparative running times which were used in the final plan. These scheduled running times and headways will be the basis for all estimates of operating expenses for the final recommended plan and for the three alternates.

6. It is a basic assumption of all studies, furthermore, that all existing District of Columbia Transit Co. and all suburban bus and rail operations will be modified, eliminated, or initiated as is necessary to achieve a completely integrated system of rapid transit and local transit throughout Washington metropolitan area; i. e., all necessary local transit routes will serve as feeders to rapid transit or express bus operations, as developed.

The foregoing is virtually a restatement and clarification of the scope of the engineering contract, but it does have points of its own. Explicit recognition is given of the necessity to revamp local transit in the light of the requirements of and diversions resulting from the proposed transportation network. It unequivocally assumes the responsibility of including in its report estimates of revenue, upon being provided with the fare schedule and estimates of riding to be provided by other consultants. It recognizes the importance of the rush hours of home-to-work and work-to-home travel peaks in Washington, which has no other similar travel peak; for example, such as the weekend thronged travel of some of the other metropolitan centers. The required tabulations and desire line charts to assist in accommodations for such peak-hour travel have not been obtained. The provision and expectations for same will be covered later.

The next response of the engineering consultants and indicative of the practical approach to transportation problems occurred when initial allocations of passengers and vehicles to the three patterns of transportation arteries were released. For highways these were on a free-flow basis, a stylized concept initially lacking in appeal to the engineering consultant, from whose letter of October 21, 1957, the following quotation is given:

It is becoming increasingly clear to me that a few unfortunate decisions were made in connection with the original assumptions given to (the traffic consultant). The first that all of the freeways, both the radial routes and the inner belt freeway, were assumed to be capable of providing for free flow at design speeds at all times—in other words, in making these assignments each freeway was assumed to have infinite capacity. As a matter of fact, experience on virtually every freeway which has been built in large metropolitan centers has proved that even with traffic somewhat under the limits of ultimate capacity of the thoroughfare, speeds during peak periods are reduced substantially below the 45 miles per hour generally assumed for travel on freeways in urban areas. Actually there are many instances, particularly on the west coast, where all traffic is slowed to speeds of 20 to 30 miles per hour or even less.

The second fallacy in the assumptions as made, in my opinion was the failure to assume—despite the fact that the metropolitan area's population was assumed to increase 50 percent in a 25-year period; despite the fact that with acceptable expansion factors, the number of person trips would increase from somewhat more than 3 million in 1955 to 6 million in 1980; despite the fact that the inner belt freeway and certain radial freeways would be constructed—that no major improvements would be made to the existing street system in any portion of the metropolitan area and that the circumferential traffic as well as the district-to-district travel would either use the new freeways or be confined to the use of such thoroughfares as now exist. This omission of any use of the proposed intermediate circumferential belt route, for which I understand most of the right-of-way has now been acquired, is particularly unfortunate in this connection.

The combination of the two fallacious assumptions must have resulted in the allocation of numerous trips between districts in the intermediate and outer zones over a high-speed radial freeway for a short distance on the inner belt freeway and outward over a second radial freeway to accomplish a trip which could undoubtedly be made more conveniently and with less travel time over a cross-town thoroughfare which might be logically assumed to exist in the year 1980.

The assignments used for the purposes of developing preliminary transportation plans were those supplied by the traffic consultant scaled by 10 percent. Authority for this assumption is found in the exchange of correspondence, November 5 and 6, 1957, between the survey project director and the traffic consultant, from which the following paragraphs are quoted:

Survey project director to traffic consultant, November 5, 1957:

The initial assignments, following your first estimate were made to give direction to the engineering consultants, our staff and others, in ascertaining the general nature and location of future transportation requirements, both as to mass transportation and highways. It was also intended that it would provide a working base for a cooperative endeavor with the local highway engineers. We agreed in our telephone conversation that the first set of projections could serve this purpose but should be considered as being between 10 and 15 percent higher than would be expected in the final results. Would you suggest that these be reduced by a certain percentage for working purposes, and if so will you name the percentage?

Traffic consultant to survey project director, November 6, 1957:

You raise a question about the general correction of the data in the travel patterns which you now can produce from the tabulations at hand. While the 10 to 15 percent figure which we mentioned is an average one and applies throughout the area, we think that it would be entirely appropriate for you to reduce the movements uniformly by 10 percent for the projected years. This, of course, will not give complete accuracy because the variances between zones or districts

is what we need to reconcile, and you must appreciate that an overall correction cannot achieve this.

The point of the traffic consultant is well taken; a cross-the-board cut will not respond to the traffic flow at different times and locations. It is like the proverbial quandary of the man who died in waters of an average depth of 4 feet.

The original assignments were made to a highway system essentially as furnished by the respective highway departments, which consisted of plans as far as they had developed them (see p. 3, second par., minutes of January 13 meeting of expert advisory group). A time-ratio method of route evaluation was considered effective for distributing traffic. With respect to highways the traffic diversion curve for freeways shown as figure 1 in the November 21, 1956, circular memorandum to division engineers of the Bureau of Public Roads was adopted, concerning which there is no question. Resulting traffic flows at certain of the interchange junctions called, on the basis of given assignments, for 18, 22, 25, and 30 lanes, implications of which can require a reduction of free flow speeds, additional highway facilities, increased use of existing roads, or a combination thereof. Each increase of travel time by virtue of reduced speeds requires a new calculation of the resulting traffic diversion.

Thereafter the engineering consultant submitted a preliminary plan for the 1980 highway system. This showed outer and intermediate circumferential belt routes, numerous new or improved divided primary roads (6 lanes in the District of Columbia and 4 lanes otherwise), for segments of which traffic assignments are requested. New connecting arteries are shown as corridors, and not as specific routes, and will so appear in the final plan. Possible interchange locations are indicated; the whole plan being a considered response to given estimates of future travel requirements. It is believed approximately 300 miles of freeway are envisaged with estimated costs to construct of $3,100,000,000 given orally by the engineering consultants. About 8 percent of the mileage is existing.

With respect to traffic diversion for improved public transit versus freeway and local streets a separate curve was developed by the board of experts, based on a modification of the diversion curve growing out of the 1957 Chicago area study. The mass transportation survey curve shows 100 percent diversion when travel time by public transit is half that of the time required by private automobile and no diversion when travel time on public transportation is 50 percent higher than by private automobile.

Assignments were made on the assumption that out-of-pocket costs are equal, regardless of mode or route, and that standards of comfort for improved public transportation facilities are equal in all respects to travel by private car; both assumptions being marked oversimplifications. Time saving is an important element in a preference for public transportation, but far more information is necessary than is apparently now available, of the part motivation plays in the use of the private automobile versus public transportation.

Assignments were made with provision for the availability of express buses and for three variations of the transit system. There is in spite of the additional facilities a disappointing reduction in the number of lanes required at points of heaviest flow. Seventy-five percent of the traffic is diverted from local transit facilities only 25 percent from projected freeways.

From the directional diagrams and initial assignments the engineering consultant submitted a preliminary 1980 rapid transit plan, a single copy of which was available. This is a combination rail and express bus plan which is in a state of flux, awaiting the receipt of revised travel assignments. The rail system may operate to a considerable extent underground. The use of the median way of highways is not apparently proposed; in fact the integration with the highway system is not evident at this stage. Union Station is given less significance as a focal point than in the thinking of the survey staff. Branches are shifted, because of the ascertained unavailability of railroad rights-of-way, etc. Stations and external parking areas are located. It was anticipated that preliminary rapid transit plans were possibly beyond 1980 requirements but that these would be cut back as final assignments were reviewed. In the opinion of one influential member of the panel of experts, as expressed in the February 11, 1958, meeting of such board, the approach now proposed, i. e., a basic two-system approach, auto-dominant and automobile, rapid transit (either rail or bus as volumes and other considerations proved) was sounder and more logical than the earlier proposals; final calculations, however, by the consultants to contain a financial evaluation on the three-way basis as originally proposed.

Final traffic assignments are now being awaited, and the staff's interpretation of the details to be applied with respect to such final assignment is found in the memo dated February 20, 1958, by the survey project director; the only new, pertinent material dealing with peak and off-peak analysis, as follows:

> 3. *Peak and offpeak analysis.*—In order to obtain a more accurate analysis of highway and transit requirements, it was agreed that the traffic consultant should segregate peak-hour trips for 4 hours of the day 7 to 9 a. m. and 4 to 6 p. m. by applying the hourly percentage of trips by each of the 4 purposes, as found in the 1955 origin and destination survey. These four trip purposes are work, commercial, social, and miscellaneous. This process produces a single 4-hour percentage in each trip purpose category; this 4-hour group will be assigned to the several transportation facilities.
>
> The highway-transit consultants, in cooperation with the traffic consultants, then will apply their judgment as to the peak design hour. The judgment will then be guided by known traffic demand variations as found from current highway and public transportation volume counts in Washington and elsewhere. Also, they will similarly supply judgment to determine directional distribution in this peak design hour.
>
> Base (offpeak) periods for the remaining 20 hours of the day will be handled in a similar manner in order to ascertain total daily transit passenger revenue and 24-hour highway demand.

COST OF ENGINEERING SERVICES

As a matter of record, the commitment to the engineering consultants is given, namely $96,000. Originally payment of services was to be made:

$30,000 on completion of three basic transportation plans
$30,000 after completion of final plan
$25,000 upon presentation of preliminary report
$11,000 upon completion and acceptance of all work.

This was changed, February 24, 1958, to:

$30,000 after completion of preliminary highway and public transportation location studies

$15,000 on submission of recommended rail-and-bus rapid transit plan
$15,000 on submission of recommended highway plan
$25,000 on submission of final report
$11,000 upon completion and acceptance of all work.

In explanation of the proposed change in the schedule of payments the survey project director wrote to the planning director of the National Capital Planning Commission, under date of February 19, 1958, as follows:

> The program of work outlined in the March 18, 1957, contract was disrupted through the inability of the traffic consultant to produce traffic data until much later than was anticipated at the time the contract was signed. In order to accelerate the engineering program to be conducted by De Leuw, Cather & Co., it was necessary to alter the sequence of the work. This has resulted in the preparation of a preliminary highway transit plan to which traffic assignments are about to be applied.

It is understood that processing of the first payment of $30,000 is underway.

VII. Miscellaneous Technical Services

In the spring of 1956 a contract involving $9,000 was entered into with Burton H. Sexton, a traffic and transportation consultant of Washington, D. C., for an analysis of the commuter service on railroads and intercity buses serving the Washington National Capital region. The volume of commuters ascertained is small. The consultant found that on a normal weekday there are 6,771 commuter passengers departing from Washington terminals by intercity bus and rail; the total commutation arrival and departure trips were estimated by him as about twice the departures, approximately 13,000, the largest point of origin being Baltimore. The consultant could find no trends in future commuter riding, because of a claimed lack of comparative data.

This study is inconclusive, to be kind. Though the amount of commuter travel may be modest, the Sexton report should not be considered the final word on the subject.

A parking survey consisting of an inventory of parking facilities within the District of Columbia was also contracted for, under which somewhat in excess of $4,000 has been paid to the District of Columbia Parking Agency.

VIII. Regulatory; Fiscal, Organizational and Managerial Aspects

Under date of September 29, 1955, a contract for $10,500 was entered into with Jerome M. Alper, Esq., a lawyer of Washington, D. C., for a report to "contain various possible means of regulating one or more systems of transit or other public transportation facilities which could be operated throughout the National Capital region including special attention and discussion as to the suitability of some type of interstate compact between the District (possibly Congress), Maryland, and Virginia and comparing the latter with related merits of a Federal agency or those of some cooperative agreement other than by compact."

Each of the various possible means of regulating such facilities were to be discussed from both a practical and legal standpoint, with comparisons made between them, and with recommendations including reasons.

Where legislation by Congress or the respective State legislatures or any combination thereof would be needed to put into effect any plan discussed, the report was to contain suggestions at least as to the substance of proposed legislation and by which body or bodies it should be enacted; the report was also to contain an actual sample of necessary legislation which might be needed to put into effect or carry out the means or recommended plans.

The Alper report dated December 14, 1955, called attention to the fact that under the existing organization of regulation, four utility regulatory commissions are exercising jurisdiction over transit operations in the Washington metropolitan area. Intrastate traffic in Virginia and Maryland is subject to the jurisdiction of the State corporation and public service commission respectively. Intra-District traffic is subject to regulation by the Public Utilities Commission of the District of Columbia. The Interstate Commerce Commission has jurisdiction over interstate traffic.

The report concludes that simplification of regulation is necessary and that this objective can best be attained by its centralization in a single agency. To that end the report recommends cooperative regulatory action of the States through an interstate compact.

The nature and scope of such an interstate compact can be found in the bill (S. 326) recently passed by the 1958 Virginia Legislature to establish with the State of Maryland and the District of Columbia the Washington metropolitan area transit regulation compact creating a Washington Metropolitan Area Transit District and a Washington Metropolitan Area Transit Commission for the regulation of and planning for mass transit by a single agency in the metropolitan area of the District of Columbia.

The powers, functions, and duties spelled out for the Commission are those one would naturally expect it to possess, inheriting in effect the attributes of the respective agencies it replaces within the specified area. One novel feature is an advisory traffic and highway board, composed of the Chairman of the Commission, the heads of the traffic and highway departments of each of the signatories and of the affected counties and cities, a representative of both the National Capital Planning Commission and National Capital Regional Planning Council, and a representative of each local and regional planning commission within the area. This board is to make recommendations with respect to traffic engineering, including the selection and use of streets for transit routing, the requirements for transit service through the area and related matters.

Centralized transit regulation is doubtless a commendable step in advance, but its urging at the moment may well be deferred until a clearer conception is arrived at with respect to the breadth of powers which will be required effectively to further the transportation needs of the area.

For another and not totally unrelated phase of the problem, a $15,000 contract was entered into October 24, 1956, with the Institute of Public Administration, New York. This called for a report on the major organizational, managerial, and fiscal problems arising from

plans for a transportation scheme fitted to 1980 requirements. The assignment involves ways of financing deficits of any proposed transit system, as determined by the engineering studies; a study of the organizational and administrative problems of financing and operating a regionwide express bus or other mass-transit service; study of problems of financing and administering an automobile-oriented system, and consideration of the Federal Government's role in planning, financing, and regulating transportation facilities in the National Capital region.

Nothing concrete has been seen in satisfaction of the foregoing specifications, but doubtless, on the known repute of the institute, an adequate presentation will be duly submitted. There is ample evidence of its satisfaction of another requirement of the contract; namely, to sit with the Chairman of the Commission and other consultants to discuss major alternatives and policy problems encountered in the study and in the development of conclusions and recommendations.

A second contract was subsequently entered into with the institute, likewise for $15,000 for the preparation and editing of the final report, which is now under way, and for studies of fare structure, etc. With respect to the last, the mass-transportation survey group intends to rely mainly on one of its expert panel, a specialist in this field.

IX. The Next Step

Despite presently unresolved traffic volume projections, and much unfinished business on the part of principal contractors to meet the specifications of their contracts, it is probable that the mass-transportation survey will be concluded by June 30, 1958. There is always a risk of miscalculation or omission attendant upon a pressured end of an assignment. To illustrate, the traffic consultant finds (letter dated October 31, 1957) that—

> most of the conditions which produced abnormally high trip generation are attributable to short cuts which were taken in order to expedite the completion of the tabulations and to more nearly conform to your production schedule.

Just what form the recommended final transportation plan will take is not unascertainable at this writing. It is surmised that it will take the form of a combined highway, rail, and bus rapid-transit system in the nature of the preliminary scheme, with considerable construction underground and without recourse to median lanes. In any event, the cost will be staggeringly high and operating deficits not unlikely. It is not anticipated any strikingly new transportation developments will be incorporated. Cost estimates, as provided by contract, will be by unit prices, colloquially known as horseback estimates and certainly not definite enough to envisage financing. New proposed highway arteries will be delineated by the engineering consultant as roughly conceived corridors. Artificial assumptions of free-flow speeds and equal costs and comfort, conditions not to be found or expected in real living are likely to give way to realities. These aspects are mentioned to emphasize the provisional and preparatory character of the transportation proposals.

To carry on the mass-transportation survey, the National Capital Planning Commission has asked Congress for an additional $60,000, the money to be used for—

Printing and binding report	$15, 400
Expert, Apr. 1 to June 30, 1958	4, 600
Clerk-stenographer, July 1, 1958, to June 30, 1959	4, 210
Transportation engineer, GS–15, July 1, 1958, to June 30, 1959	12, 690
Contractual services, professional organizations	21, 500
Miscellaneous	1, 600
Total	60, 000

The foregoing represents a gross underestimate of what is required for a more proximate realization of a modern transportation setup. It is more nearly a prelude to mothballing.

Ten needed avenues of further endeavor are enumerated in no intended order of priority:

(1) Inasmuch as new rapid-transit facilities will be costly, it is necessary to have some assurance of their use. Time-saving is undoubtedly an important deciding factor, but when it comes to public transportation, which generally has lost patronage, much additional light, particularly in an auto-dominant community, is needed of the motivation of potential users.

(2) Also, because of the cost of a conventional system of rapid transit, further exploration of alternatives and new modes is necessary—in other words, more intensive consideration of travel technology. The one new facility, the carveyor, proposed by the survey project director, was turned down hard.

(3) Proposals for land use need to be reconsidered in the light of transport-system design—both are interacting.

(4) Inasmuch as the plan will be a book plan, extensive field studies are needed in confirmation and in modification.

(5) Closer cooperative relations need to be established with Congress, public officials of the affected States and the District, and with highway officials.

(6) From 1948 to 1955 noticeable changes occurred in travel habits. These need to be currently studied. Methods of traffic estimation require proof.

(7) Operators of local transit, bus, and commuter rail facilities need to be conferred with. Usually a transportation plan starts with the existing system and developments proceed therefrom. The current survey started afresh to build an entirely new scheme, with the risk of collapsing present transit facilities.

(8) Parking agencies, taxicab operations, and trucking interests need to be represented to achieve a fully integrated transport plan.

(9) The further cooperation of regional and local planning agencies is required.

(10) The emerging plan can benefit greatly from the advice of businessmen and financial interests. The financing of transportation development has become critical.

The mass-transportation-survey group is poised to make its contribution. From that point on further consideration of the area's transportation problem should be turned over to a more broadly represent-

ative group, termed by your staff director a "Metropolitan Transportation Development Board," to translate the technical findings of the mass-transportation survey into an action program, and to direct the transitional steps needed to convert the existing mass-transportation system into one responsive to the future needs of this dynamic community.

The foregoing, as has been pointed out, requires a greatly intensified effort, a determination of step-by-step implementation and more detailed and considered attention to individual problems concerned with and proposals leading to an integrated transportation plan.

The estimated cost of the program which has been outlined is $200,000, a modest sum when compared with the amounts provided for like purposes in other cities, for example, San Francisco. Relevant to such endeavor is the expressed hope of your staff director that Congress with or without action then or subsequently by Maryland and Virginia will establish a permanent continuing Metropolitan Transportation Board; this is borne out of the realization that the achievement of an adequate transportation system will not be the work of any one year.

APPENDIX

The following memorandum, dated October 22, 1957, is the best available description of the techniques employed by the mass-transportation survey to project transportation needs of the metropolitan area. The memorandum is further identified in the text, page 15 above.

WASHINGTON METROPOLITAN TRANSPORTATION SURVEY

URBAN TRAVEL PROJECTIONS AND ASSIGNMENTS TO HIGHWAYS AND TRANSIT—1956 AND 1980

The traffic studies just completed for the Washington metropolitan area may be divided into three distinct stages as follows:

1. Analysis of 1948 and 1955 origin-destination surveys and derivation of traffic generating characteristics common to both.
2. Estimates of the volume and distribution of future travel in the Washington area (1965 and 1980).
3. Assignment of projected travel to future transportation systems (express highways and high-speed transit).

Study area

The 1948 and 1955 origin-destination survey areas were almost identical. The 1948 external cordon was located at the extreme fringe of urbanization. By 1955 most new populations had located within the cordon so that the new cordon was changed but little. The two surveys are thus comparable on an area basis.

Area within the cordon lines has been subdivided at four levels: "sectors," "districts," "zones," and "subzones." The central business and governmental center was designated "sector 0" in both studies, but sector boundaries were changed in 1955 to include a much larger area than in 1948. Eight other sectors, radiating from "sector 0" were somewhat reduced in size.

The area within each sector is divided into districts. The 1948 study area consisted of 65 districts. The 1955 cordon contains 68 districts, those in sector 0 somewhat larger than in 1948, and those near the cordon which experienced large population increases, made smaller.

Each district was further subdivided into zones and subzones. Since projections of population and land uses to future years have been refined only to the district level, the analyses reported here were carried at that level.

Traffic enters and leaves the survey area on a number of roads and highways which cross the cordon. In 1948 traffic was interviewed at 35 roadside stations in the cordon. The 1955 study included interviews at 38 cordon stations.

The origin-destination surveys

The design of the origin-destination studies was very similar in both 1948 and 1955. Four basic interview surveys were made:

1. Home interviews at a cross section of dwellings:
   (*a*) In 1948, 1 dwelling in every 20.
   (*b*) In 1955, 1 dwelling in every 30 in the District of Columbia—1 dwelling in every 10 in Maryland and Virginia portions of the area.
2. Truckdriver interviews from a sample of all trucks licensed at addresses in the study area.
3. Taxi trip reports from driver manifests and taxidriver interviews.
4. Roadside interviews of car and truckdrivers entering and leaving the study area.

Addresses of trip origins and destinations were obtained in each study, plus information on trip purpose and time trip was made. The home interviews also obtained data on the number of persons in each dwelling; number of cars owned, and the mode of travel used in making trips.

Population in the study area in 1948 numbered about 1,110,000 people who accounted for 1,837,000 trips; they owned 203,464 cars. By 1955 population within the cordon numbered nearly 1,570,000 people who made 2,757,000 trips and owned 418,497 cars. Residents thus accounted for 1.66 trips per person per day in 1948 and 1.76 trips per person per day in 1950. Car ownership increased from 184 cars per thousand population in 1948 to 267 cars per thousand in 1955.

Analysis of 1948 and 1955 surveys

The 1948 and 1955 surveys contain information on the travel performed in Washington at those dates. What we really want are estimates of the traffic needs in the area at future dates. Projection of travel to future years must, of course, be related to conditions which are likely to exist at those dates.

What can we predict about future population growth in Washington? The National Capital Planning Commission has made detailed studies of growth trends in the Washington area, has determined the amount of land available for development, and has predicted the most likely uses of such land. Thus, the Commission can estimate with reasonable detail, the number and probable distribution of persons and labor force and the location of employment and retail trade throughout the area for a few years into the future.

Can the generation of urban travel be related to such predictions of population and land use? A number of studies show that they can be. In developing these relationships, the National Capital Planning Commission and the National Capital Regional Planning Council have collaborated with Mr. Hoover's staff in preparing similar statistical data for the years that the origin-destination surveys were made and the years 1965 and 1980 to which traffic projections are desired. Statistics have been developed for districts and zones within 1948 and 1955 cordons and for planning areas which correspond roughly to districts beyond the cordon. Coverage beyond the cordon includes the remainder of Montgomery and Price Georges Counties in Maryland and Fairfax, Loudoun and Prince William Counties in Virginia. The following statistical series have been developed:

1. Population.
2. Dwelling units.
3. Labor force.
4. Employment.
5. Median-income group.
6. Retail sales (dollars and percent of regional total).

The origin-destination surveys also provide information on car ownership. This consultant has prepared estimates of cars owned in each district for 1965 and 1980.

Trips per person

The first step in trip analysis has been to find out how many trips people make and develop correlation between the number of trips and area on some of the statistical series listed above. The fact that there are two origin-destination studies of different date which must be reconciled is a very important point. A good correlation is not always representative of cause and effect, and the second study can be used to check correlations derived from the first.

Analysis of the 1948 data showed that trips made by the residents of each district could be expressed as trips per person in the district when related to the number of cars owned by the residents; the distance from the district to the center of sector O (a measure of decentralization); and the number of opportunities for trips (trip generators) within a short distance of the district.

In what way is each of these factors related to the generation of trips? Car ownership is, to some degree, a measure of wealth. Car ownership also increases with distance for sector O—partly because transit service is focused on the central business district and frequency of service decreased with distance from central business district. Distance from sector O (measured as travel time by car) is a measure of decentralization. Urban densities are less as this distance increases. Fewer trips can be made on foot, so more must be made by car or transit. Higher income families tend to live in the newer areas which are further from the central city as the area grows. Isolation, the third factor, becomes important because most trips people make are relatively short. If there are no nearby generators, people tend to make fewer trips. Thus districts adjacent to the cordon tend to produce fewer trips than less-isolated districts which are otherwise equal.

The variables just described correlate quite well with 1948 origin-destination data. A similar correlation has been developed for the 1955 study. But the two studies do not agree. Investigation found that car ownership was not as good an indication of income level in 1955 as it was in 1948. Low-income families

now have nearly as many cars as high-income groups. Car ownership is still significant, but income level must also be taken into account. When this is done, a four-variable formula is developed which provides equally good estimates of trips for either survey.

Trip ends

Every trip has two ends. Most trips have one end at the residence of the person making the trip. The other end is at a place of work, business, social, or other purpose.

The basic formula described above will provide an estimate of the number of trips made by residents of each district. Now we must determine mode of travel, purpose of trip, and the pattern of trip distribution between residence and other land uses.

The next step in this study is definition of trip purpose. Travel was recorded for 10 purpose classifications in the origin-destination studies, but these have been reduced to 4 categories in this study, with "home" considered as a special class. The 4 purposes are "work," "commercial" (shop, business, eat meal, medical-dental), "social" (social-recreational, school), and "other". The first 3 classes have 1 end of each trip at home. The "other" trips have neither end at home and include taxi trips plus all other tips made from "work to work," "work to or from commercial," and "commercial to commercial."

Two of the purposes for which trips were recorded in the home interviews have been eliminated. "Change travel mode" does not represent a new trip purpose, but a switch from one mode of travel to another during a single trip. "Home to CTM" trips have been eliminated and trips to or from CTM and other purposes are assumed to begin or end at home. This procedure is used only to determine the number of trips for each purpose and does not affect analysis of the origin-destination pattern. "Serve passenger" trips made by auto drivers have also been canceled. In Washington, most of these represent trips by a car-pool driver, picking up or delivering his passengers. The drivers' main purpose is his work trip, of course, so trips made from home serve passenger to work (or other principal purpose) are assumed to begin at home and an equivalent number of "home-serve passenger" trips have been canceled. Of course, some drivers actually have no purpose except to serve passengers—the wife taking her husband to the bus stop; the mother taking kids to school. These trips have been preserved and have been placed in "social" category because it is felt that most of them are short and remain near the home.

One other special trip category has also been recognized. Some of the trips produced in each district begin or end outside the study area. These trips increase from a small porportion of trips by persons living near the center of the city to a relatively large proportion by persons who live near the cordon. A curve has been developed which expresses external trips as a percentage of all trips made by residents in each district. These trips are assumed to be of social-recreational character, though a few are for work or commercial purposes.

Trip purpose

Work travel is the most basic of the trip-types. The ratio of labor force to population is about the same in all districts of the city, and the need to travel to work produces about the same number of trips in each group of persons. However, low-income groups make more trips on foot and fewer by car and transit.

The proportion of work trips to all other types of travel varies decreasingly with distance from city centers. The relationship is remarkably regular, and results from various factors. Low income groups live near the city center, and have less money to spend on travel for purposes other than work. Some nonwork purposes are within walking distance in densely populated areas, with less need for travel. Thus, in Washington, half or more of the trips made by residents living within 10 minutes of the District Building are made to and from work. Fewer than 30 percent of the trips made by most of Montgomery County residents are for work, reflecting the effects of both decentralization and high income.

The proportion of trips made for "commercial" purposes—shopping, business, medical-dental—increases with distance from "sector O" and with higher income level. The same pattern holds for social trips. Miscellaneous trips are also a higher proportion of the travel made by higher income residents living away from the center of the city—probably because most of the miscellaneous trips are made in cars, and cars are used for more of the travel performed by these people.

Mode of travel.—Each purpose-of-trip category has been analyzed to establish the proportion of trips performed by car (driver or passenger) or transit. The principal factors in each case are (1) car ownership, which indicates the availability

of cars for use by drivers and passengers, (2) income level, (3) driving time from "sector O" (reflecting decreasing quality of transit service) and (4) whether the district of residence is outside or within the District of Columbia. The latter element has been introduced because most of Capital Transit's operations cease at the District of Columbia line and the bus companies which serve Maryland and Virginia provide less frequent service.

The effects of income, distance from CBD, and car ownerships are quite regular within the District of Columbia for each of the three main purposes. Outside the District, car ownership is at about the same level everywhere and has no special significance.

Auto passengers have been established for each purpose category as an "auto occupancy" factor. For work travel, the factor varies with car ownership, more passengers riding in cars from areas of car ownership. Decentralization (distance from center of city) is factor of some importance in the commercial-trip category, each car carrying more passengers in a given income range in the suburban districts. The occupancy of social trips is heavily influenced by distance.

Miscellaneous trips.—As already noted most miscellaneous trips (work-work, work-commercial, commercial-commercial trips) are made by car. Occupancy of cars is low (about 1.25 persons per car including driver), with no particular pattern of variation.

External trips.—Only the travel made by area residents can be analyzed in the way described above. As noted, some of their trips begin or end beyond the cordon, and the number of these can be estimated. There are other trips to and from the city which are not made by residents.

Between 1948 and 1955 the total volume of external traffic at the cordon increased about the same proportion as population. The pattern of trip distribution within the city for both years appears to be inversely related to a distance between each district and cordon station and directly proportional to the number of trip attractions in each district.

Truck trips.—Truck trips made in each district can be predicted by relating them to three population groups. The number of dwellings (residential generation) and the number of persons employed in governmental and nongovernmental categories. Special consideration has to be given the CBD and a few of the more industrialized districts.

Taxi trips are strongly oriented toward areas of employment and commercial activity. These are the areas which generate the miscellaneous trips. In these studies, taxi trips appear to have the same pattern as miscellaneous trips and have been grouped with them.

Distribution of trips

The origin-destination pattern of trips has also been developed by purpose. The number of work trips generated by residents (labor force, or LF) must be balanced by the number of trips to and from jobs (employment). The same must be done for commercial trips by residents by prorating or otherwise accounting for trips by residents in the several commercial centers in Washington.

A satisfactory method has been developed to establish the number of trips generated at "nonhome" terminals—work, commercial, or social.

Distribution of trips between origins and destination is the next problem. Plots of data, by purpose, found that the rate of travel between origins and destinations is inversely related to the distance between trip generators and directly proportional to their size. Thus, short trips are made at much higher rate than long ones, and the decay with distance is a regular, predictable pattern. The rate of decay varies with trip purpose and is steepest for miscellaneous and social trips. Work trips decay slower than others, so have the longest average length.

Intradistrict trips are an important part of travel in some parts of the metropolitan area. Districts at the outskirts tend to be larger than those near the center, with the result that more travel takes place entirely within the district. Isolation is another factor. If there are relatively few attractions within a reasonable distance, a higher proportion of the trips generated in a district will remain in it. Rockville is an extreme example (district 29), in which about 30 percent of all trips were intradistrict in 1955.

Intradistrict trips can be estimated with reasonable accuracy, and adjustments made to the interdistrict travel induced by employment, commercial centers, and resident population.

Successive approximations.—When the methods described above have been applied to the distribution of trips between zones, two sets of estimates are developed for each class of trips. For instance, the work trips may first be

distributed from the residences in each district to the sources of employment throughout the city. After the formula has been applied, the number of trip attractions developed by formula are reduced to the initial estimate of work trips made by the residents. Then the formula is applied to the employment in each district to develop relative attractions to the labor force in all districts. Again, attractions are balanced to the number of work trips that employment in the district will most likely make. The result is an estimate of work trips by labor force to employment and other estimate of work trips by employment to LF.

A "successive approximations" technique can be applied to these sets of estimates in successive cycles. Each cycle produces new values for each estimate. After each cycle, the pair of estimates are more nearly alike. After 3 or 4 cycles, most pairs are very similar. Average values are then accepted from the final cycle as representative of travel between districts.

Projecting trip patterns to 1965 and 1980

The estimates of population and land use prepared by the National Capital Planning Commission and the National Capital Regional Planning Council represent future conditions against which to apply the characteristics derived from study of the 1948 and 1955 origin-destination surveys.

The urbanized area is expected to expand considerably by 1980. Using the 1980 population estimates as a guide, 62 "districts" have been added to the 68 within the 1955 cordon. The additional districts are larger than those in the 1955 study so that the study area is more than doubled. The same area was studied for 1965 and 1980 projections.

The procedures derived from analysis of the origin-destination studies have been applied and travel patterns developed for each year. The changes which are expected to take place in future years have led to cerrain modifications in overall travel. Car ownership is expected to increase somewhat, but many districts are presently near saturation and will not change much. Transit trips were projected on the assumption that the 1955 level of transit operation were continued. This led to increase in transit use, but not proportionately as great as population increase.

People in densely settled areas make fewer trips than persons in less dense areas. Nearly all new growth will be of low-density type, with the result that the average number of trips per residents is about 2.04 by 1980.

Taxi trips and external trips have been included in the projections to future years. Techniques for the projections of truck trips have been developed but have not yet been applied.

Assignments to express highways and transit systems

The third stage in the traffic study has been the assignment of trips to express highways and alternate system of high-speed transit. Assignments have been made between the different facilities by use of two time-ratio curves.

Express highways versus local streets.—A system of express highways which have been tentatively scheduled for construction before 1965 has been the basis for highway assignments.

The first assignment assumes that transit facilities of the type presently in Washington will constitute the only transit service by 1965 and 1980. Therefore, the transit travel developed in the initial trip projections represents all that will use transit.

All trips projected for auto drivers will use either local streets or the express-highway system—or both. Travel time between each pair of districts has been computed for travel on local streets and travel using express highways. The shortest practical route has been chosen in each case.

Trip assignments to local streets or express-highway systems are based on the time-ratio curve described in E. H. Holmes Circular Memorandum to Division Engineers: Guide for Forecasting Traffic on Interstate Systems, Bureau of Public Roads, October 15, 1956.

Express highways versus express buses.—When a higher standard of transit is contemplated, it is expected that trips will be diverted from automobile to public transportation. Assignment procedures are complicated by the need to develop separate assignments for several different classes of trips.

Trip assignments to high-speed transit are based on a somewhat flatter time-ratio curve than that used for highways versus streets. This curve was developed by the panel of consultants which advises Mr. Hoover and his staff.

Some auto trips are considered "captive" to autos and are not assignable. Trips without a home terminus are in this class (miscellaneous trips). For each

of these trips, two other trips of home-work or home-commercial category must be set aside as "auto-oriented." Also, 50 percent of all taxi trips are considered "auto-oriented."

The transit-assignment curve must be applied separately to—

1. Local transit trips: There are the "captive" trips of the initial projections. Many of them would be immediately divertible to the new high-speed transit system.

2. Local street trips: There are the trips retained on local streets in the assignment between express highways and local streets. Both drivers and passengers are assignable to transit.

(*a*) Taxidrivers and passengers must be kept apart from other drivers. When a taxi passenger is assigned to transit, the driver will make no trip at all.

3. Express-highway trips: assignable in some way as trips on local streets.

Express highways versus high-speed transit.—Three different schemes (A, B, and C) have been tested for high-speed transit. The transit time-ratio curve mentioned above has been applied in the manner described for express-bus assignments.

Access and routing of trips.—The time ratios applied to trips between districts develops the volume of assigned travel. Mechanical techniques have been developed to route these trips to assumed points of access on each system. Between access points, trips have been routed through the shortest lengths of route to points of exit.

The routing techniques are modified applications of the methods used in the analysis of express highway system in the Detroit study. See A Mechanical Method of Assigning Traffic to Expressways, by E. Wilson Campbell, HRB Bulletin 130, page 27.

The trip volumes assigned to each section of express highway or transit route is thus a measure of demand for use of that route. The travel times upon which these preliminary assignments were based are related to facilities operating at reasonable speed.

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